

Title: The relation of Analytic and Synthetic Attentional Strategies

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Abstract: Perceptual weights give a measure of the attentional strategies individuals use in analyzing complex sounds. Analytic strategies and synthetic strategies have long been established as two opposing primary modes of parsing sonic information, but their relationship has not been fully explored. In the present study participants completed two experimental procedures. One procedure followed an analytic listening design wherein participants made a decision about the change in loudness of a single component within a sonic complex of three components across two intervals. The other procedure followed a synthetic listening design wherein participants made a decision about the change in loudness of the whole complex across two intervals. Perceptual weights were extracted from the data gathered using a correlation of each component's level and the individual's response (Lutfi, 1995; Richards and Zhu, 1994). The perceptual weights were then analyzed using root-mean-square about the ideal weighting strategy for each condition. While individuals had variation in their weighting patterns in the analytic task, a general trend emerged of individuals weighting the components in the synthetic task close to the ideal weighting pattern. The variation present in weighting patterns in the synthetic task could partly be explained by how closely to ideal an individual applies analytical weights. Analyses of these data revealed that analytic listeners performed better on synthetic listening tasks than listeners with a purely synthetic listening strategy, $t(10) = 14.23$, $p < 0.0001$.

Introduction: Perceptual weighting patterns give insight into how different individuals attend to the many parts of a complex sonic scene and how they integrate this information to make decisions about their environment. Generally, with regards to listening and sound, attention can be divided into two broad categories: analytic and synthetic. An analytic listening strategy would aim to parse each sonic component of a scene and make decisions based off the information gained from the analysis of the parts. On the other hand, a synthetic listening strategy takes in all of the available sonic information and makes decisions based on the whole sound picture, rather than the parts. Both strategies have their place and appropriate application, as much past research has shown their exclusivity (cite from paper). However, what has not received much attention from the scientific community is the relationship between these two attentional modes, particularly in how individuals may switch between these two strategies. Post-hoc analyses of

investigations that looked at both analytic and synthetic strategies had revealed conflicting results in terms of the direction of the relationship. Analysis of Stellmack, et al. and Willihnganz, et al. (1996) showed that better performance on analytical tasks translated to worse performance on synthetic tasks. On the other hand, analysis of Dye, Stellmack and Jurcin (2005) showed that better performance on analytical tasks did indeed correlate with better performance on synthetic tasks. The present study seeks to explore this relationship and determine if indeed individual's with an analytic listening strategy perform better on synthetic listening tasks than individuals that perform well only on synthetic listening tasks.

Methods & Design: Two experiments were performed. The first was an analytical listening task following a two-interval forced choice design. Participants were first presented with a cue stimulus containing the to-be-judged frequency component (the “target” frequency) always at 57 dB. The following two intervals presented a complex of all three components (253 Hz, 1012 Hz, and 4048 Hz) each with a level difference, from 57 dB, randomly chosen from a standard distribution with a mean of 0 dB and a standard deviation of 4 dB. Participants were tasked with judging whether the target frequency was louder in the first or the second interval. The second experiment was the synthetic listening task. This task used a similar procedure and the same set of stimuli as used in the analytical task but with some changes to cue and the to-be-made judgement. Participants were cued with the three-tone complex with each component at 57 dB. The following two intervals varied the level of each component and participants were asked to determine in which interval the entire three-tone complex was louder. Participants performed approximately 100 practice trials in each condition (with a 253 Hz target, 1012 Hz target, 4048 Hz target, as well as the synthetic task). A follow-up session was then scheduled with each participant to perform 200 data collection trials. Participants’ performance was first recorded as proportion correct. These data were then used to generate perceptual weights for each participant by correlating, on a trial-by-trial basis, the participant’s response with the level difference that was applied to each component (Lutfi, 1995; Richards and Zhu, 1994). These perceptual weights were then finally used to generate RMS values for each participant, for both their analytical performance and synthetic performance across all three trial conditions. RMS has been used previously as a measure of performance, comparing an individual’s deviation from the ideal (Stellmack, Willihnganz, Wightman, Lutfi, 1996; Willihnganz, Stellmack, Lutfi, Wightman, 1996).

Results: Perceptual weights were obtained for each participant; these represent each participant's individual attentional strategy. As can be seen from the graphs of these perceptual weights, participants were highly varied in their attentional strategies, however properly weighted functions were seen in several participants (proper weight refers to how closely the weighting pattern matches that of an ideal observer). As mentioned, these perceptual weights are separate measures from performance correct. Proportion correct for all participants varied between 0.44 and 0.76 across all trials. Within the analytical task, proportion correct was found to be lowest when 1012 Hz was the target ($M=0.54$), while proportion correct was highest when 4048 Hz was the target ($M=0.69$). Within the synthetic task, proportion correct was just above chance across all participants ($M=0.54$). RMS about ideal was determined for each participant's perceptual weighting functions. RMS about ideal values for participant's analytical data varied between 0.34 and 0.64 while RMS about ideal values for synthetic data varied from 0.005 and 0.045. A correlation between these data were performed ($R^2 = 0.56$). Further, a two-tailed t-test revealed that participants with perceptual weights closer to ideal on analytical tasks had perceptual weights closer to ideal on synthetic tasks, $t(10) = 14.23$, $p < 0.0001$.

Discussion: The goal of this study was to assess the relationship between analytical and synthetic listening strategies, that is whether using an analytical strategy affects one's ability to use a synthetic strategy and vice versa. Indeed, in comparing the RMS about ideal data, a strong relationship can be seen between an individual's ability to use a properly weighted analytical strategy with an evenly weighted synthetic listening strategy. The result of the two-tailed t test also indicate that properly weighted analytical perceptual functions predict properly weighted synthetic perceptual functions. These results together strengthen the conclusion that attentional switching is related to an individual's ability to use either attentional strategy effectively. This can be seen in a graph of the RMS about ideal in the analytical tasks against the RMS about ideal in the synthetic tasks. More ideally weighted analytical functions are usually accompanied by more ideally weighted synthetic functions. These findings may be used to further broader scale understanding of attention and attentional strategies, particularly in domain-general attentional models, such as models of executive function. Many such models treat executive function as a kind of computational kernel that calls different modules for specific functions. With the understanding that attentional switching is separate from a given mode of attention may allow further research into the extent to which attentional switching taxes the resources of the central

executive, or the degree to which individual's may switch, the speed with which they do, the effect that this has on other modules under the control of executive functioning, or other such basic research. Future research may also seek to explore how attentional switching and the degree of perceptual weighting in auditory tasks correlates with other related functions of executive functioning such as effortful control, planning, working memory, among others. Future investigators may also wish to see if these same results are to be found in other sensory domains, such as visual attention. In general, the results here support the original hypothesis that as performance on analytical listening tasks improves, so will performance on synthetic listening tasks.